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Notes on the feeding habits of *Gaidropsarus guttatus* (Collett, 1890) from Faial Island, Azores, NE Atlantic, PT

by

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Résumé. – Notes sur les habitudes alimentaires de *Gaidropsarus guttatus* (Collett, 1890) de l'île de Faial, Açores, Atlantique NE, PT.

Gaidropsarus guttatus est un prédateur nocturne des fonds rocheux des îles de Macaronésie. Il n'existe pas d'étude sur l'écologie alimentaire de cette espèce et cet article apporte les toutes premières informations, sur la base d'un échantillon de 82 individus capturés à l'île de Faial, aux Açores (Portugal). Les prélèvements ont été réalisés entre août 1997 et avril 1999 dans des mares intertidales et en zone subtidale jusqu'à une profondeur de 10 m. Sur les 82 spécimens collectés, 95% d'entre eux présentaient des aliments dans l'estomac, totalisant 303 proies de 11 taxons différents. Les proies les plus fréquentes étaient des décapodes (45%), notamment le crabe *Pachygrapsus marmoratus* (24%). Les poissons téléostéens représentaient 17% de toutes les proies identifiées. La présence significative de proies benthiques et d'algues dans les contenus stomacaux de *G. guttatus* suggèrent que cette espèce est un prédateur opportuniste qui utilise la succion pour capturer ses proies.

Key words. – Lotidae – *Gaidropsarus guttatus* – Azores – Feeding habits – Prey items.

Gaidropsarus guttatus (Collett, 1890) was recently allotted to the family Lotidae (see Froese and Pauly, 2012) within Gadiformes, which includes several species of elongated, agile fish, dwelling in caves and rocks, possessing a single anal fin, highly specialized otoliths, complete fusion of ostium and tail and a reduced egg diameter (max. 1 mm) (Nelson, 2006).

Gaidropsarus guttatus is characterized by a large rounded head with three sensitive barbells, two over the nose and one below the chin. Its overall colour is brownish with dark blotches that expand well over the second dorsal fin. The belly is creamy light beige. Maximum standard length is believed to be around 26 cm. Although this species is normally found in intertidal pools and low depths down to 10 m, some records refer it to occur as deep as 120 m. *Gaidropsarus guttatus* is quite probably a rare endemic species to the Macaronesian Archipelagos of Azores, Madeira and Canaries (Svetovidov, 1986a; Saldanha, 1995; Porteiro *et al*., 2010).

The feeding behaviour of this species, as well as most of its ecology, is almost totally unknown with only minor references of its occurrence in checklists and similar publications (see Froese and Pauly, 2012) where, for example, a small note refers that it feeds by suction on decapods and algae (sic).

In this paper, which belongs to a series of publications that aim to describe food webs and predator-prey relationships in the Azores (e.g. Morato *et al*., 2001; Figueiredo *et al*., 2005), we examine and describe the feeding habits of *Gaidropsarus guttatus,* thus indicating a first accurate description of the place of this species in Azorean rocky coastal food webs.

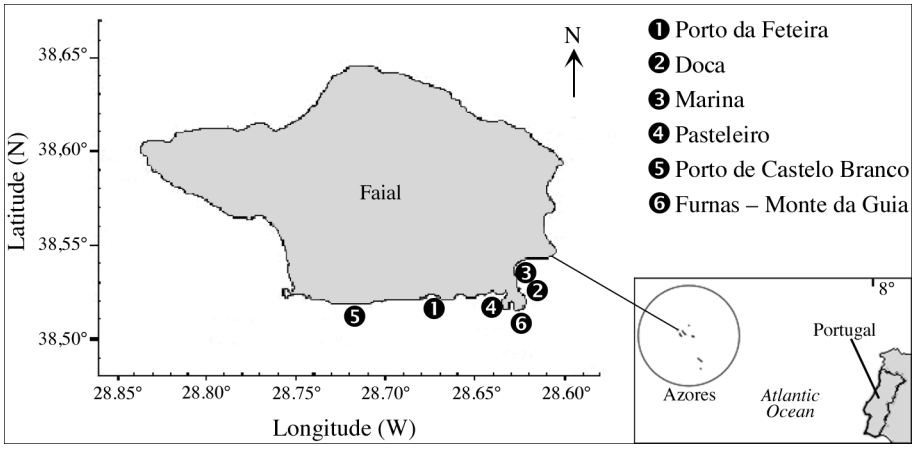

Figure 1. - Map showing Faial, within the Azores Archipelago, NE Atlantic, and collection *Gaidropsarus guttatus* sites.

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MATERIAL AND METHODS

Sampling

Between August 1997 and April 1999, 82 specimens of *Gaidropsarus guttatus* were collected in six different sites from Faial Island (Fig. 1), ranging from tide pools to sub tidal shallow waters (max. depth 10 m). After collection with small aquarium nets and anesthetic (Chinaldine 10% solution in acetone), all specimens were measured (total and standard lengths, TL and SL respectively) to the nearest millimetre and weighed to a precision of 0.01 g. Sexing was tried albeit not always possible (see below) and otoliths were collected for posterior otolithometry (work in progress). Stomachs were quickly removed from the esophagus to the pyloric valve in order to quickly stop digestive processes. After weighing to a precision 0.001 g, all stomachs were preserved in a 10% formalin solution.

Stomach contents were macroscopically checked and prey identification reached the lowest possible taxonomic level, sometimes using microscopes and lenses, depending on the state of digestion and size of each item. For identification purposes, and whenever needed, reference literature was used: (Barnes, 1990; Wirtz, 1995) for some invertebrates and Saldanha (1995) for crustaceans and some fish. Humid weight for each item was registered after excess liquid was extracted with absorbent paper.

Sample representativeness

In order to correctly describe the feeding biology of a given species it is necessary to examine a sufficient number of stomach contents/prey items (Cailliet, 1977; Mauchline and Gordon, 1985; Rodrigues, 1991). For this purpose, we used the classic method proposed by Hurtubia (1973), in which we related the cumulative trophic diversity (using Shannon's *H'* Index) and the random analysis of the stomach contents as given by equation (1) (Mauchline and Gordon, 1985; Magurran, 2004):

$$H' = -\sum_{i=1}^{n} Pi(\log_e Pi) \quad (1)$$

where *H'* = trophic diversity index; *n* = number of taxa; and *Pi* = proportion of the prey *i* within the total of observed preys.

This equation was applied to 1000 different randomized orders of analyzed stomach contents to produce a cumulative diversity curve that would be representative of the whole sample (Figueiredo *et al*., 2005). The number of stomachs needed for a correct description of a species' diet is obtained when this curve tends to be asymptotic (Hurtubia, 1973). This can be verified when 2 previous diversity values from a given number of samples (*H'*) are between a scale of ± 0.005*H'* (Alonso *et al*., 2002).

Diet description

The following indices of Mohan and Sankaran (1988) were used to determine main preys of *G. guttatus*:
Percentage of occurrence (%Oi):

$$\%Oi = \frac{ni}{\sum_{i=1}^{i=n} ni} \times 100 \quad (2)$$

where *ni* represents the number of stomachs with food item *i*;
Percentage of weight (%Wi):

$$\%Wi = \frac{Wi}{\sum_{i=1}^{i=n} ni} \times 100 \quad (3)$$

where *Wi* is the weight of *i*;

Relative importance percentage (%Rw):

$$\%Rw = \frac{Q\sqrt{\%Wi^2 + \%Oi^2}}{\sum Q\sqrt{\%Wi^2 + \%Oi^2}} \times 100 \quad (4)$$

where

$$Q = \frac{45 - |\theta - 45|}{45} \quad (5) \text{ and } \theta = Tan^{-1}\left(\frac{Oi}{Wi}\right) \quad (6)$$

These indices were used to obtain a general characterization of the diet and we opted to group dominant preys in grand groups (e.g. Algae, Cephalopods, Decapods, etc.) in order to facilitate the interpretation of results. Non-dominant or occasional preys were grouped together into a category named "others". Indices %Oi, %Wi and %Rw were also calculated for each group of prey as well as to prey items that we did identify until species level. This would give us a better knowledge of the most representative preys of *G. guttatus*.

RESULTS

From the 82 sampled specimens, ca. 84% were collected at night (n = 69 specimens), 79% were females, 7% males, while for the remaining 14% sex determination was not possible. Sizes (SL) of specimens ranged between 10.9 cm and 23.5 cm (corrected

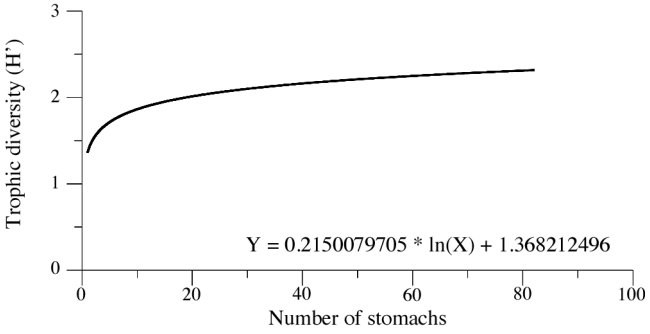

Figure 2. - Relation between cumulative trophic diversity and number of analyzed stomachs of *Gaidropsarus guttatus* from Faial Island, Azores.

Table I. - Prey items found in stomachs of *Gaidropsarus guttatus* (n = 82) from Faial Island, Azores, NE Atlantic. %Oi: frequency of occurrence; %Wi: weight importance; %Rw: relative importance.

Food items	%Oi	%Wi	%Rw
Algae	10.37	0.67	6.41
Porifera	0.47	0.25	0.33
Gastropoda	2.83	0.11	1.74
Polychaeta	1.41	0.45	0.91
Crustacea	34.43	68.54	47.90
Isopoda	5.18	0.23	3.20
Caprelidea	2.35	0.07	1.45
Mysidacea	8.49	0.22	5.24
Decapoda	30.66	65.26	45.04
Unid. Crustacea	4.24	2.75	3.14
Echinodea	0.94	0.07	0.58
Teleostei	8.96	25.23	16.74
Unid. items	6.60	0.83	4.11
Inerts	17.45	3.82	11.04

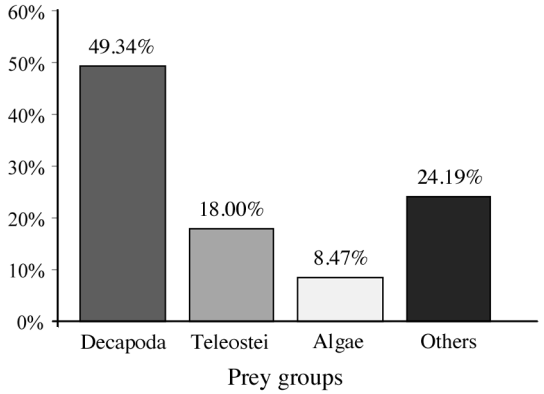

Figure 3. - Index of relative importance (%Rw) regarding the major prey items found in the stomachs of *Gaidropsarus guttatus* from Faial Island, Azores.

Table II. - Decapod species found in the stomachs of *Gaidropsarus guttatus* from Faial Island, Azores, NE Atlantic.

Decapod species	%Oi	%Wi	%Rw
Scyllarus arctus	3.70	0.01	2.46
unid. Majidae	3.70	1.51	2.67
Xantho pilipes	1.23	12.06	8.19
Xantho incisus	2.46	2.33	2.28
Xantho sp.	1.23	0.73	0.96
Grapsus grapsus	1.23	3.16	2.28
Pachygrapsus marmoratus	18.51	30.50	23.98
Pachygrapsus maurus	3.70	6.24	4.88
Plagusia depressa	2.46	3.09	2.65
Planes minutus	4.93	0.84	3.33
unid. Decapoda	56.79	39.49	46.28

median 16.8 cm). No significant differences or correlations were found between sizes and sex of collected fish.

From the 10th analyzed stomach, the sample becomes representative (Fig. 2) thus allowing a correct characterization of this species' feeding ecology. We can prove this by calculating the difference between the cumulative trophic diversity (0.048 *H*'), which is attained in between the 8th and the 10th observed stomachs.

Only 5% of the stomachs – all from night caught specimens – were empty. The other 78 contained 303 prey items, belonging to 11 different taxa (Tab. I).

The values of %Rw clearly show that dominant preys in *G. guttatus* diet are decapods. This is equally confirmed by both %Oi and %Wi values. Teleost fish and inert items are also representative in stomach contents.

The relative importances of the grouped food items are represented in figure 3 were decapods again appear as highly dominant.

While decapod crustaceans are clearly the major group of preys found in our sample of *G. guttatus*, there is also a major species within this group – *Pachygrapsus marmoratus* (Fabricius, 1787) – that is obviously the most important food item for this species (Tab. II).

Species *Xantho pilipes* A. Milne-Edwards, 1867 and *Pachygrapsus maurus* (Lucas, 1846) also show an important numeric presence in the stomachs as well as those decapods that we were not able to identify.

DISCUSSION

The high percentage of *Gaidropsarus guttatus* collected after sunset and the fact that they were hunting clearly indicates this species as a nocturnal predator, in agreement with the updated database by Froese and Pauly (2012). These authors also refer decapod crustaceans and algae as major food items although, in our sample, fish showed to be more important than algae. This could well be due to the characteristics of the Azorean tide pools and shallow water communities (see Morton *et al*., 1998). Fishes from the family Lotidae comprise six genera and 21 species according to a recent revision by Froese and Pauly (2012) following Nelson (2006) update. These data show that the few studied species do prey mainly on decapod crustaceans. The best known species from this family is also the only freshwater one: *Lota lota* (Linnaeus, 1758), which is known to feed on insects, crayfish and other invertebrates, as well as fish for larger specimens (Etnier and Starnes, 1993).

The simple fact that *G. guttatus* is most of the times – in spite of the few literature that deals with this species – referred as a bottom dwelling species over rocky bottoms and feeding on benthic species (Saldanha, 1995; Morton *et al*., 1998) allows us to agree with Shpigel and Fishelson (1989) assumption that this is indeed an opportunistic predator. Such an assumption is reinforced, in our opinion, by the presence in the stomachs from our sample of such items as inert material, small parts of echinoderms and algae. This also suggests some degree of involuntary ingestion of epibenthic materials due to the fact that *G. guttatus* captures prey by suction (Froese and Pauly, 2012).

No other species of this genus is known to occur in the area (Porteiro *et al*., 2010). However, similar species from European waters do seem to have similar diets: *Gaidropsarus biscayensis* (Collett, 1890) (Svetovidov, 1986b) *G. mediterraneus* (Linnaeus, 1758) and *G. vulgaris* (Cloquet, 1824) (Cohen *et al*., 1990) are all referred to feed mainly on crustaceans.

In the Azores islands, crustaceans also appear, significantly, in the diet of the related Gadiform *Phycis phycis* (Linnaeus, 1766) (see Morato *et al*., 1999) although several Perciformes are also crustacean feeders albeit with less expression of importance in their diets [e.g. *Epinephelus marginatus* (Lowe, 1834) (see Barreiros and Santos, 1998), *Diplodus sargus* (Linnaeus, 1766) and *Labrus bergylta* Ascanius, 1766 (see Figueiredo *et al*., 2005)]. Although possible, diet overlap involving *G. guttatus* with other fish species in Azorean tide pools is yet to be determined. The same applies to *Octopus vulgaris* (Lamarck, 1798), a widely distributed cephalopod and known crab eater along its vast geographical distribution.

The appearance of *Pachygrapsus marmoratus* as a dominant prey is probably due to its wide abundance in Azorean coastal habitats, a fact described by many authors and early summarized by Silva (1997). Many other decapods would appear at a species level if we could have been able, when studying the stomach contents, to properly identify many highly digested items. However, this common situation in stomach content analyses is usual and does not take away the clear dominance and importance of *P. marmoratus* in the diet of this Azorean sample of *G. guttatus*.

Because there are no other works yet published on the diet of this particular species, we could not compare our results with data from the other Macaronesian Archipelagos, from where this species is, most probably, endemic (see Wirtz, 1995; Santos *et al*., 1997; Porteiro *et al*., 2010). Therefore, this study did accomplish its main goal, which was to produce a first characterization of the feeding of *Gaidropsarus guttatus* from specimens collected in the Azores. This is a non-commercial species, apparently common but vulner-

able due to its limited area of occurrence. This paper is one more contribution towards understanding Azorean coastal food webs. With this particular species our objective is to extend its study to Madeira and the Canaries while we are already preparing a paper that deals with its reproductive biology.

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